

Aerodynamics of Magnetic Levitation (MAGLEV) Trains

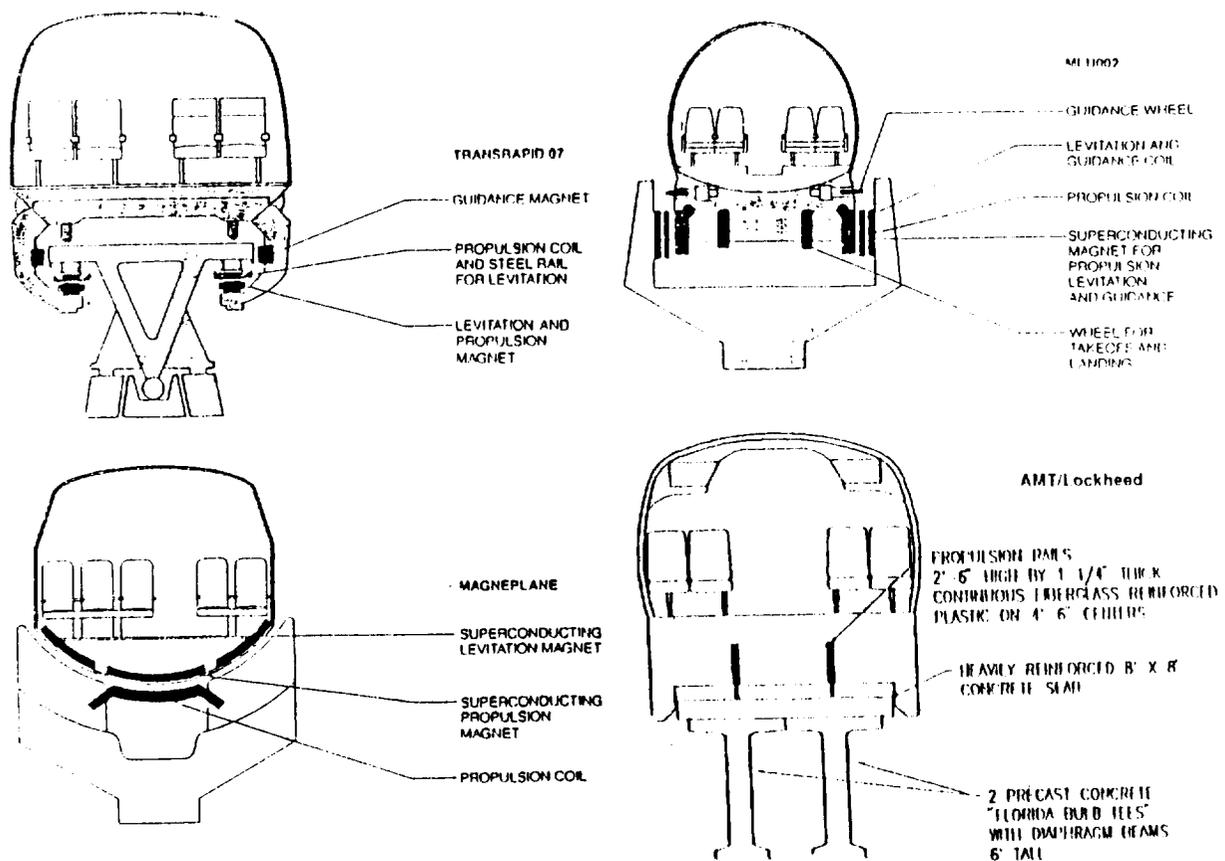
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Blacksburg, VA

**Transportation Beyond 2000:
Engineering Design for the Future**

September 26-28, 1995

Magnetic Suspension Systems

The different systems that have been proposed have a large influence on vehicle configuration design.

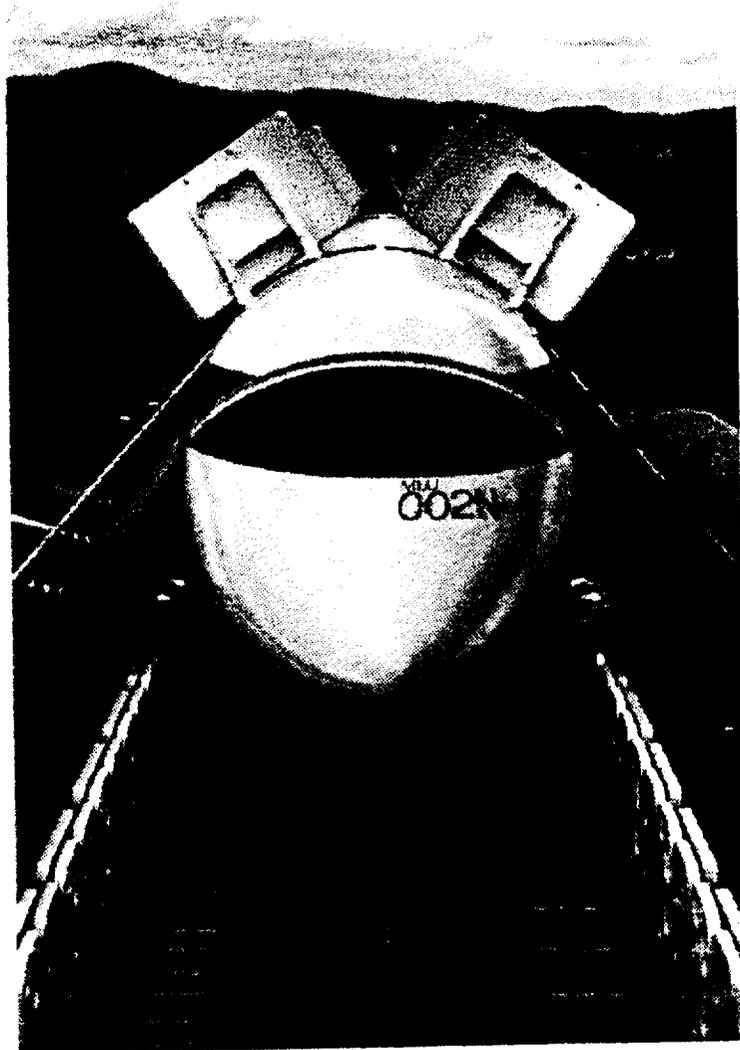


German Test Vehicle

There are ongoing test vehicle programs in Germany and Japan.

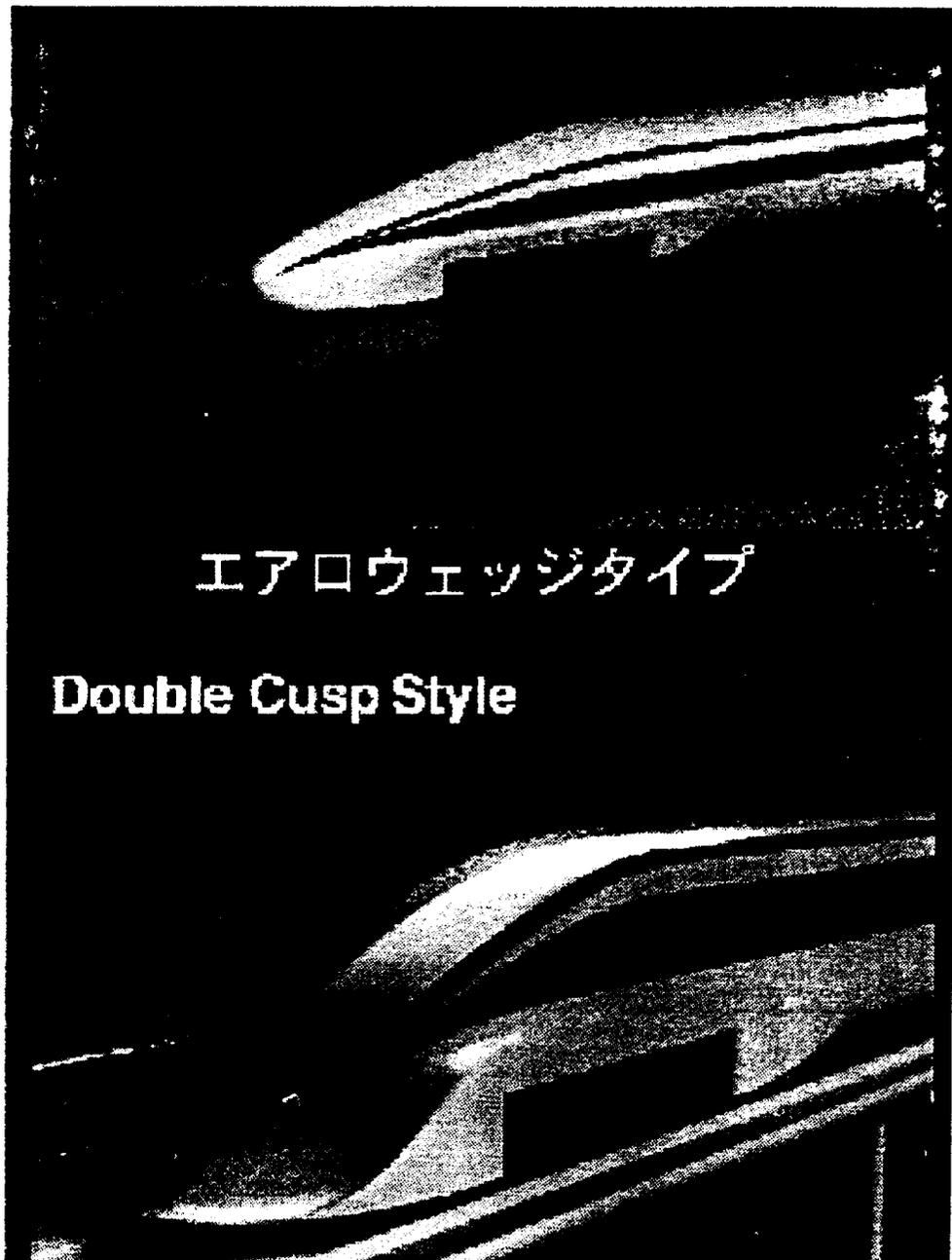


Japanese Test Vehicle



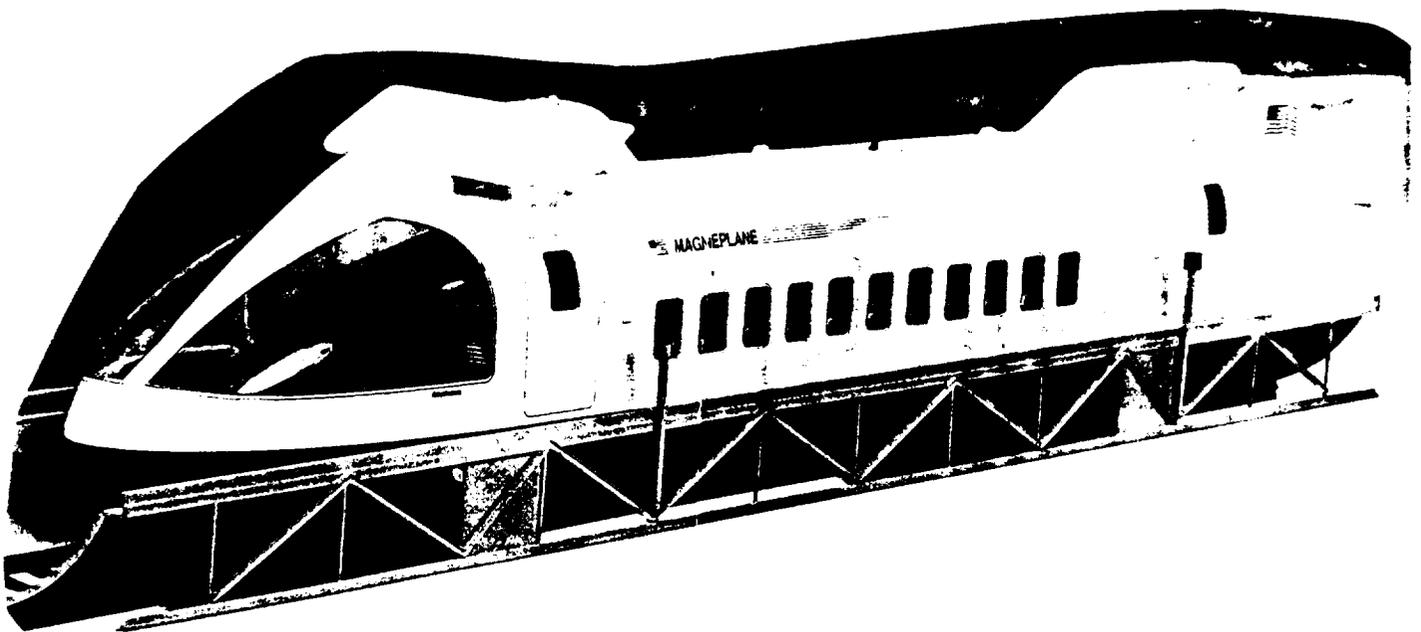
Proposed Japanese Designs

The Japanese have developed new designs to minimize aerodynamic forces, noise and tunnel entry/exit problems.

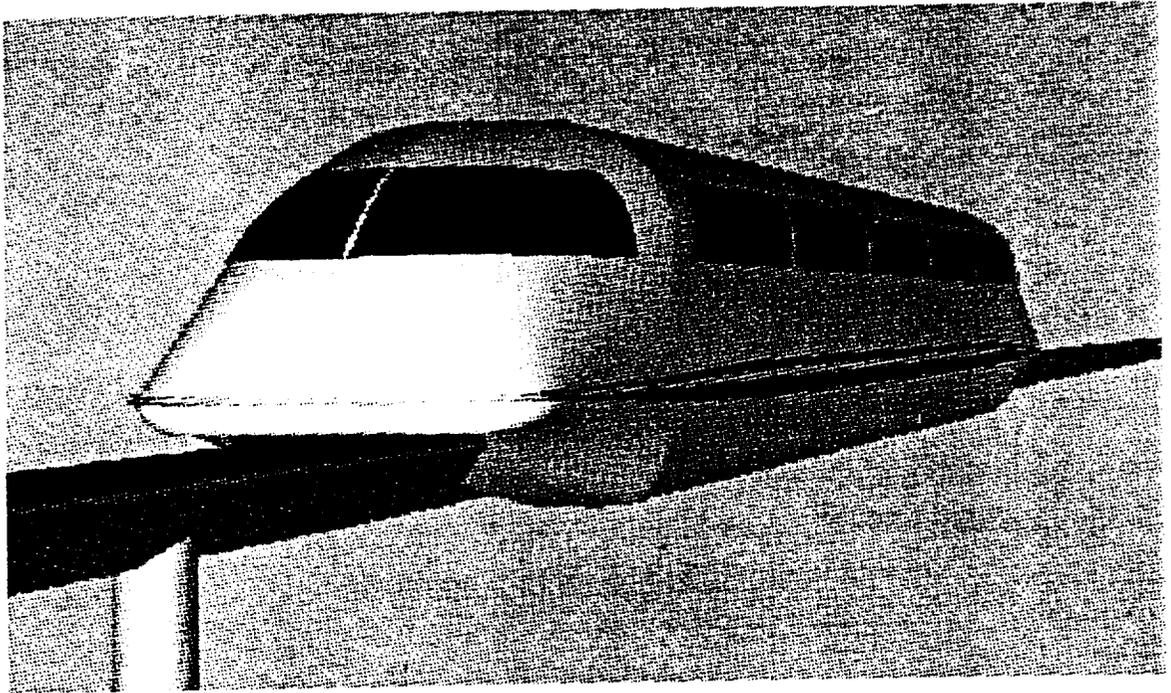


Proposed US Designs

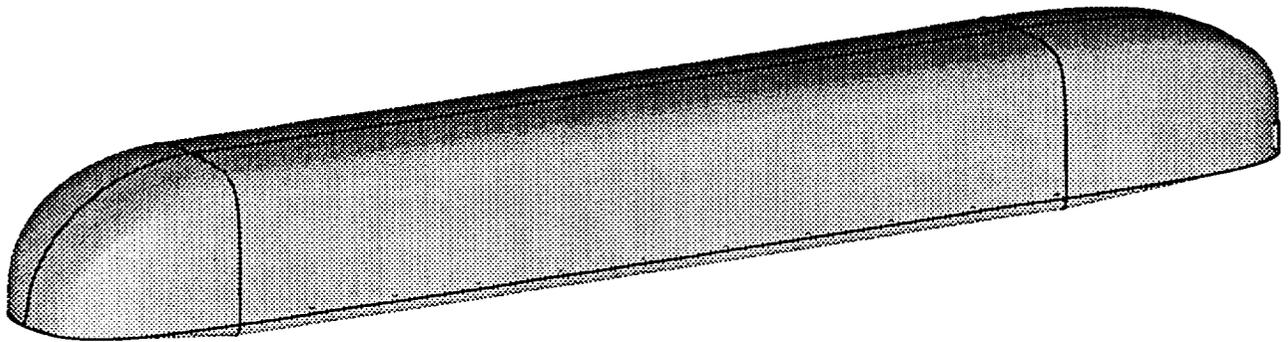
There are several US designs that have been proposed.



Grumman Designs



Lockheed Design for AMT



Need for Wind Tunnel Studies

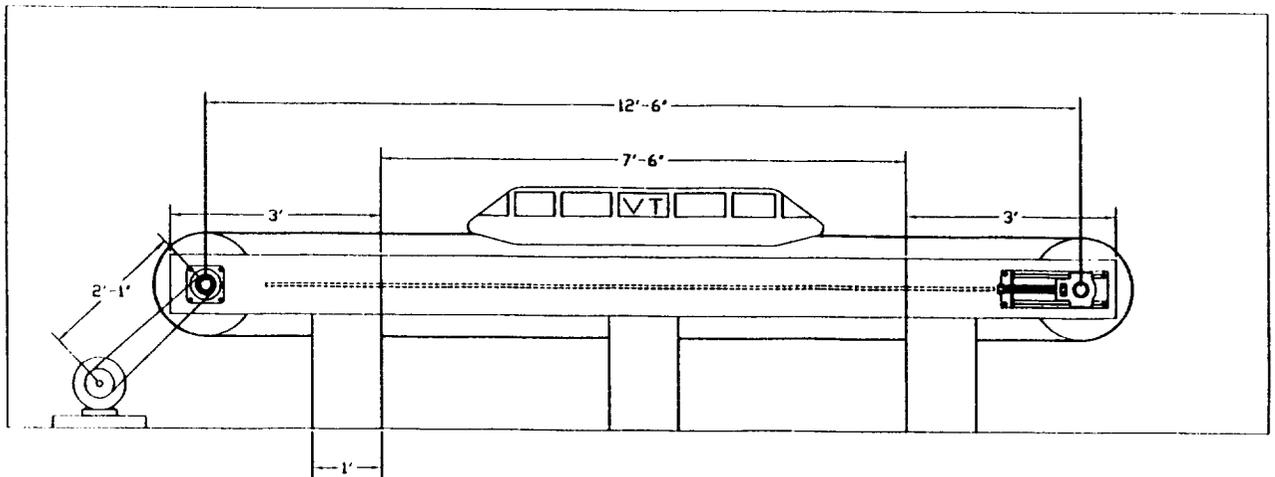
- + There is little relevant data in the literature
- + The analytical estimates for drag vary widely
- + CFD is unreliable and very expensive for 3D flows with separated regions

Wind Tunnel Tests of Maglev Vehicles

- + Model ground effect of track with a moving belt
- + Model clearance between elevated track and ground (approx. 3 diam.)
- + Parallel, uniform incoming flow to model accomplished with proper shrouding
- + Reynolds number simulation with a "trip" strip

Moving Belt System

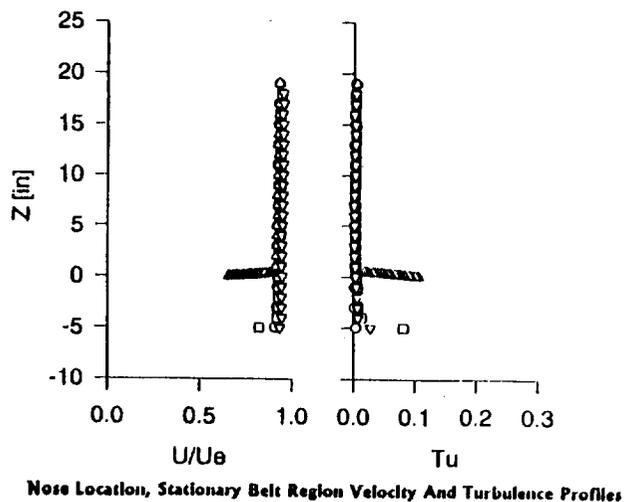
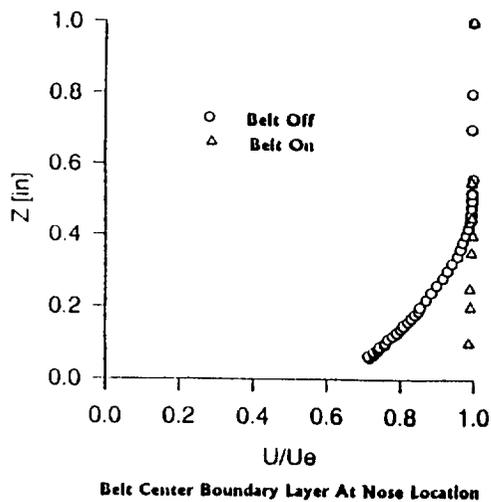
- + Use in VT 6 ft. X 6 ft. Wind Tunnel
- + Accommodate 6 ft.(long) X 1 ft.(diam.) model
- + Maximum belt speed



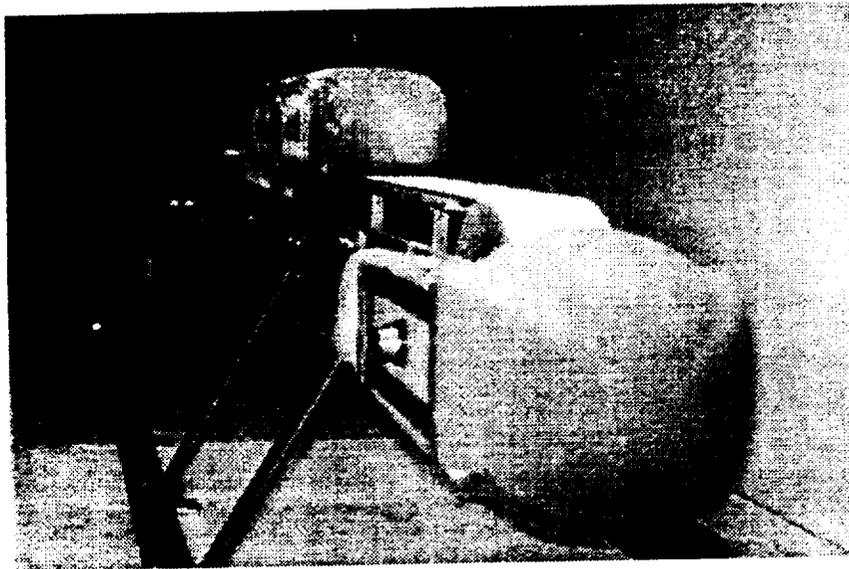
SHROUDING NOT SHOWN

Incoming Flowfield Verification

- + Hot-wire measurements at various locations above and around the belt
- + Mean-flow and turbulence profiles



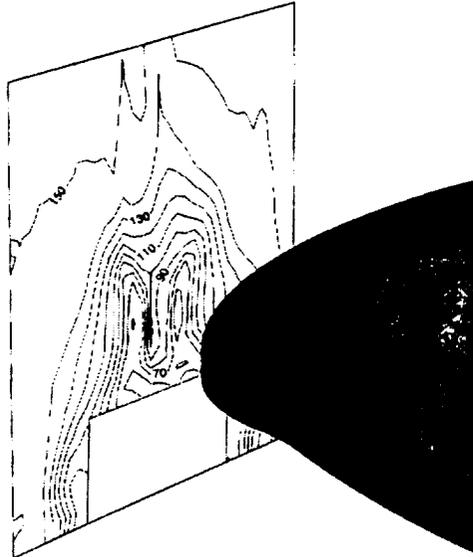
Northrop/Grumman Model in the Wind Tunnel with Moving Track



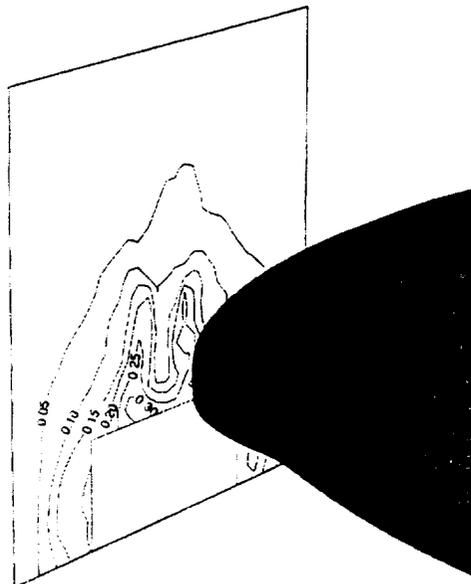
Experimental Methods

- + Force and Moment balance
- + Tuft surface flow observations
- + Hot-wire flowfield surveys
- + Surface pressure distributions
- + Skin friction gages

Typical Flowfield Surveys

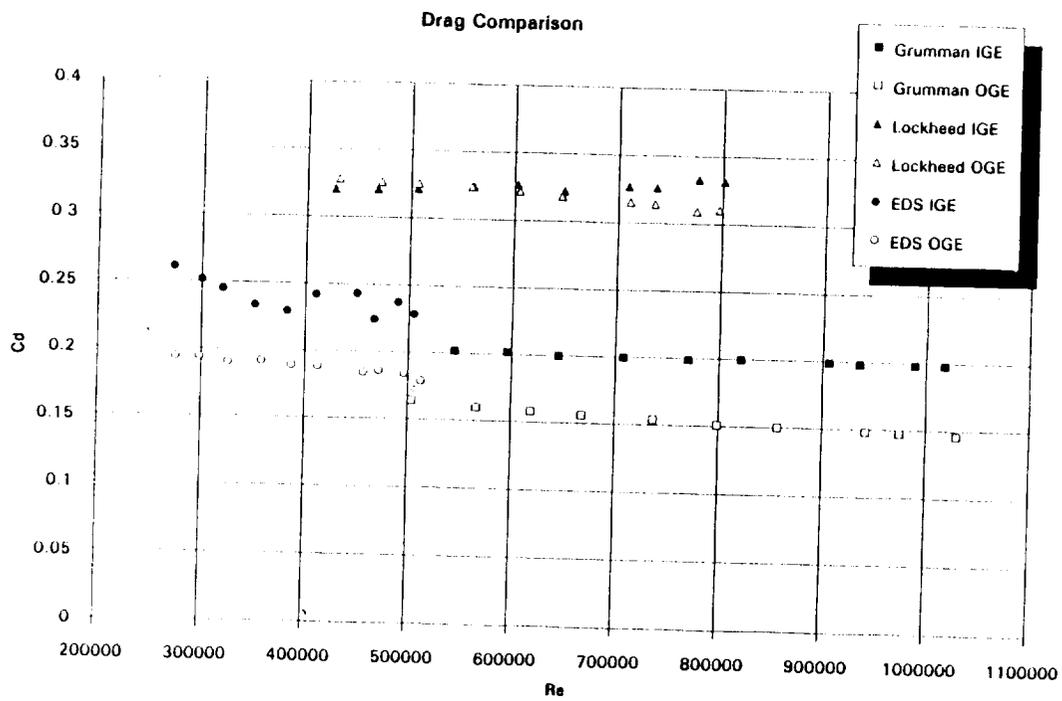


Velocity Contours Aft Of Tail

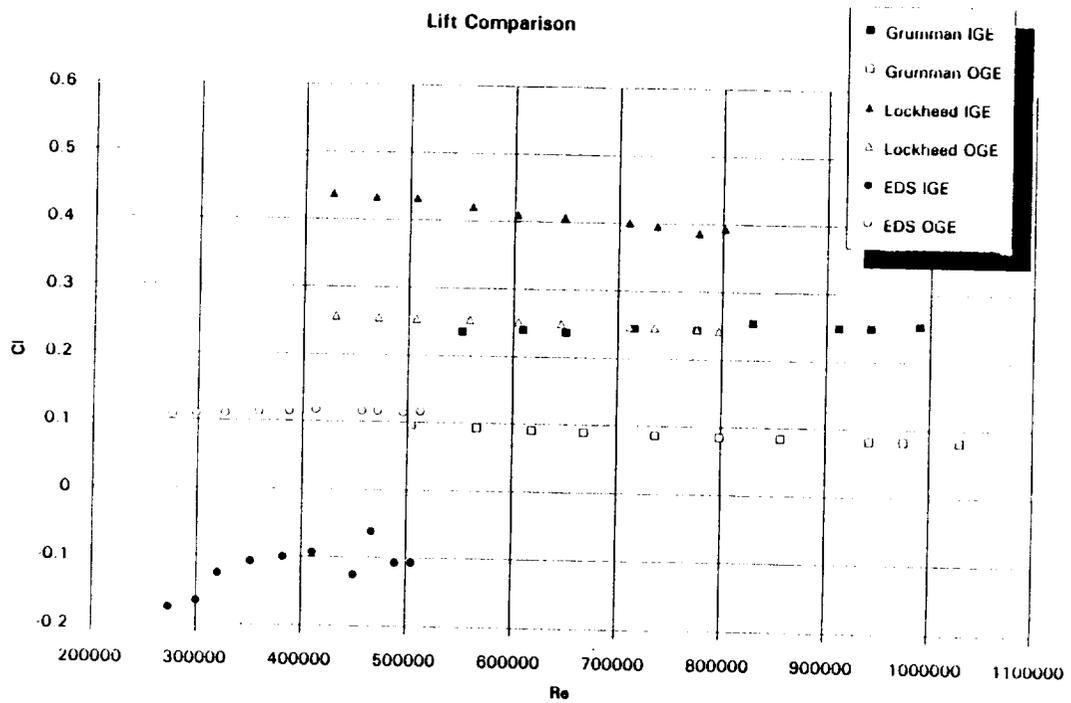


Turbulence Contours Aft Of Tail

Wind Tunnel Data



Wind Tunnel Data



MultiDisciplinary Design

Design Considerations

- ◆ **Aerodynamics**
- ◆ **Structures**
- ◆ **Control**
- ◆ **Propulsion**
- ◆ **Cost**
- ◆ **Transportation utility**

MultiDisciplinary Design

Aerodynamics

- ◆ Low Drag, Lift and Moment
- ◆ Low noise
- ◆ Cross winds
- ◆ Passing
- ◆ Tunnel entry/exit

MultiDisciplinary Design

Structures

- ◆ Load-bearing skin (like an airplane, not like a train)
- ◆ Weight
- ◆ Construction/materials
- ◆ Impact loads
- ◆ Unsteady aero loads

MultiDisciplinary Design

Cost/Shape

- ◆ Weight
- ◆ Shape complexity and tolerances
- ◆ Construction/materials
- ◆ Conventional rail cost info NG
- ◆ Some MAGLEV cost info available
- ◆ Use small transport plane cost info